US-PAT-NO: 5962858

DOCUMENT-IDENTIFIER: US 5962858 A

TITLE: Method of implanting low doses of ions into a substrate

---------- KWIC ---------

Detailed Description Text - DETX (8):

A drawback of conventional ion implantation systems is that conventional diluent gases, such as hydrogen, react with the dopant gas, such as phosphorous, during the ionization process which occurs internal to the ion source, as well as with any residue which is generated during use of the ion source and which coats the walls 18A of the ionization chamber 24. The residue which coats the ion source walls, as well as any reaction species formed by the reaction between the hydrogen and phosphorus (typical gases used for implantation), creates impurities which are subsequently implanted within the substrate S. For high dose implants, the impurities introduced to the substrate are generally within tolerable limits. For low dose implants, however, accuracy is of the utmost importance, and thus the generation of any impurities greatly affects the particular dose of ions implanted into the substrate S. Moreover, the presence of the impurities within the beam present significant obstacles to precisely controlling the dosage of the dopant ions implanted into the substrate.

Detailed Description Text - DETX (11):

The illustrated implantation system 10 is particularly suitable for implanting low doses of dopant ions into the substrate S. The illustrated diluent gas reservoir 28 introduces a noble gas, such as helium, into the implantation chamber by way of fluid conduits 32B and 30, rather than a conventional diluent such as hydrogen. The noble diluent gas is inert relative to the dopant gas, and thus does not substantially react with the dopant gas or with the residue that may coat the walls of the ionization chamber of the ion

EAST Browser - L6: (9) 3 with L with 5 | US 5814823 | Tag: S | Doc: 1/5 (SORTED) | "Full" 1/8 (Total images 8)
File Edit View Tools Window Help

 Controlling ion beam

SYSTEM AND METHOD FOR SETECING NEUTRAL PARTICLES IN AN ION BEAN

FIELD OF THE INVENTION

The present invention relates generally to the field of ion implanters, and more specifically to an improved system and method for monitoring and controlling the dopant concentration of an implanted substrate by detecting neutral particles in the ion beam.

BACKGROUND OF THE INVENTION

Ion implantation has become the technology preferred by industry to dope semiconductors with impurities in the large scale manufacture of integrated circuits. Ion energy and ion dose are the two most important variables used to define an implant step. Ion energy is used to control junction depth in semiconductor devices. The energy levels of the ions which make up the ion beam determine the degree of depth of the implanted ions. Ion dose relates to the concentration of implanted ions for a given semiconductor material. Typically, high current implanters (generally greater than 10 milliamps (mA) ion beam current) are used for high dose implants, while medium current implanters (generally capable of up to about 1 mA beam current) are used for lower dose applications.

A typical ion implanter comprises three sections or subsystems: (i) a terminal for outputting an ion beam, (ii) a beamline for mass resolving and adjusting the focus and energy level of the ion beam, and (iii) a target chamber which contains the semiconductor wafer or other substrate to be implanted by the ion beam. The target chamber typically includes a dosage control or dosimetry system which functions to accurately measure and control the dosage of ions which are implanted into the target wafer.

Dosage control systems often include a device for measuring beam current, because dopant dosage is directly related to beam current. A device such as a Faraday cage is typically used to measure beam current. Faraday cages measure beam current by trapping and measuring the charged ions in the beam while blocking electrons from entering or escaping the cage.

While charged particles can be suitably accounted for, neutral atoms in the beams present a more difficult problem because they are not detected by the Faraday cage and therefore do not contribute to the measured beam current. Thus, neutral atoms in the ion beam are not considered when calculating a total dosage based on the Faraday cage measurements. Because neutral atoms may have essentially the same energy as ions, however, they are implanted into the wafer and contribute to the total dopant concentration. If significant neutralization of the beam occurs, the Faraday cage will provide a false measure of the true implanted dosage of the substrate.

The extent of neutralization of the beam depends in part upon the pressure within the beamline. If the beamline vacuum pressure is sufficiently low, the implanted species is ideally a singly charged positive ion of the particle which is selected by the mass analysis magnet. If the pressure is not sufficiently low, however, the ions in the beam may change charge state through atomic collisions with the residual background gas atoms, without undergoing a significant change in energy. In addition, the extent of beam neutralization also depends on the composition of the residual background gas through which the ion beam propagates. Neutralization of the beam is particularly problematic when implanting semiconductor surfaces such as photoresists, which tend to outgas or sputter, thereby altering the composition of the residual background gas. In either case, the beam striking the Faraday cage may be sufficiently neutralized so as to possess a considerable fraction of atoms of enough energy to be implanted into the substrate, yet not be counted by the Faraday cage as part of the total beam flux, which includes both charged ions and neutral particles.

One manner of monitoring the dosage of atoms being implanted into a substrate (i.e., dosimetry control) which compensates for beam neutralization tendencies is shown in U.S. Pat. No. 4,539,217 to Farley, which is commonly owned by the assignee of the present invention and incorporated by reference as if fully set forth herein. Farley automatically compensates for implanted ions which have been neutralized by interactions with gas atoms in the flight path to the wafer being implanted. Compensation is based on the fact that the collisions of the primary positive ion beam with gas atoms along its path causes electrons to be added to or taken away from some of the singly charged positive ions with a probability which can be scientifically determined. The probability depends upon, and is a function of, the ion species, the ion velocities (energies), and the composition and pressure of the residual background gas through which the ion beam passes.

By measuring these parameters, the determination of implanted dosage, which is primarily based on the Faraday cage beam current measurement, may corrected to account for neutral particles. The dosage measurement is compensated upwards (to prevent overdosing) based on a determination of the extent of ion beam neutralization, which does not contribute to the Faraday cage beam current measurement yet which does contribute to dosage. The dosage measurement is compensated downwards (to prevent underdosing) based on a determination of the extent of doubly charged ions, which only contribute to dosage as much as singly charged ions yet which are counted twice by the Faraday cage as contributing to ion beam current.

Farley assumes that over a wide range of pressures encountered in the beamlines of implantation devices, the function is essentially linear. A single measurement of pressure at a particular point in the beam is taken and assumptions are made regarding a pressure path integral along the beam. Based on the assumption, partial pressure components for each location in the beams may be determined. A measurement of the ion beam current from a Faraday cage versus pressure is thereby input into the implanter control system to generate a correction signal which compensates for the change in detected neutral particles as the pressure varies. This process, known in the art as pressure compensation, allows the implantation dose to be accurately monitored and controlled.

However, the pressure compensation technique used in dosage control systems is flawed in that assumptions regarding both the pressure and the composition of the residual background gas may change during the implantation process. For example, the composition of the residual background gas may change due to a vacuum leak. In addition, the calibration of a pressure gauge used to measure the pressure at a particular point in the beam may drift. Further, the pressure distribution along the beam may change due to variations in vacuum pumping speeds or from outgassing or sputtering rates from the substrate being implanted. Still further, both pressure and residual background gas composition are made difficult to measure by outgassing of photoresist from the substrate being implanted, which contributes hydrogen and water to the residual background gas. Moreover, even if the exact pressure and composition of